UNITED STATES AIR FORCE MATERIALS TECHNOLOGY HIGHLIGHTS

Air Force Research Laboratory

Materials & Manufacturing Directorate

Wright-Patterson Air Force Base • Dayton, Ohio   Spring 1998

Addition To Materials And Manufacturing Directorate Provides Airbase Operability, Environmental R&D

With the recent creation of Air Force Research Laboratory, the services lead laboratory for airbase operability and environmental research and development became part of the Materials and Manufacturing Directorate.

The Directorate's Airbase and Environmental Technology Division, located at Tyndall AFB, Fla., provides technologies aimed at: producing innovative research for solving civil engineering global mobility and agile combat support problems; assessing and managing environmental risks associated with developing weapon systems or Air Force industrial operations; developing mechanisms, processes, and models to reduce the environmental costs associated with developing new and maintaining existing weapon systems (this includes restoration of contaminated operational sites); and guaranteeing pollution prevention by assuring cost-effective compliance methods for environmental laws and regulations.

"Our division brings a wealth of knowledge, information and capabilities to the Directorate, with a clear focus on pollution prevention and Air Expeditionary Force-related technologies that will enhance the Directorate's ability to support the warfighter," said Col. Neil J. Lamb, division chief.

The Division consists of four branches: the Air Base Technology Branch, the Environmental Technology Development Branch, the Basic and Applied Research Branch, and the Integration and Operation Branch.

The Airbase Technology Branch develops advanced airbase infrastructure technologies needed to assure peacetime and wartime air-deployable electric power, environmental control systems and shelters; rapid restoration of operating surfaces; unexploded ordnance clearance, fire protection, and crash rescue. This Branch uses emerging technologies to reduce airlift requirements for deployment of airmobile base support systems; reduce logistics and manpower requirements for establishing and sustaining an airbase; enhance force protection for deployed personnel and critical assets; and provide automated mine and unexploded ordnance clearance capabilities.

"Solving Tomorrow's Environmental and Agile Combat Support Challenges Today"

The Environmental Technology Development Branch researches and develops environmentally friendly materials and materials processes; ways to reduce, control, and mitigate hazardous environmental contaminant effects; systems for monitoring and modeling contaminants in air, water, and soils; and ways to treat hazardous material waste from the manufacture, operation, and management of Air Force weapons systems and industrial processes.

The Basic and Applied Research Branch conducts fundamental research to meet Air Force environmental technology needs. Research activities are focused within four major technical areas and include a chemical process team, an air research team, a biotechnology research team, and an analytical chemistry team.

The Integration and Operation Branch provides support to the technical Branches in the areas of tech transfer, programming and budget, financial management, computer management and support, contracting, international affairs, Science and Technical Information Office, and maintains a state-of-the-art technical information library.

"The men and women of the Airbase and Environmental Technology Division are proud to be a part of the Materials and Manufacturing Directorate," according to Colonel Lamb. "We look forward to working with the rest of the Directorate to provide the necessary technologies which will lead the Air Force into the 21st century."

Materials R&D Success Stories

Integrated Product-Process Design System Improves Automotive Industry's Simulations-Based Design Capability

Scientists and engineers at Air Force Research Laboratory's Materials and Manufacturing Directorate and TechnoSoft, Inc., have developed an advanced computer-aided design (CAD) program for improving airframe design processes.

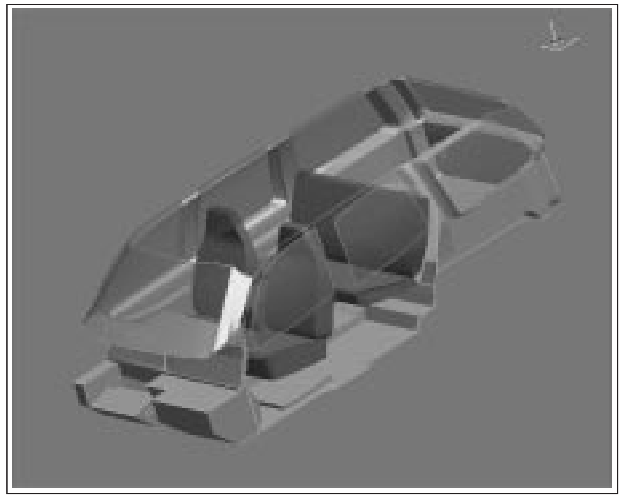
The advanced software program, called The Adaptive Modeling Language (AML™), offers the benefit of an efficient and user friendly environment in which to develop high quality product and process designs.

In the past, computer demonstrations involving feed-forward and feed-back design between conceptual and manufacturing (materials and process) design have been accomplished with dated and oversimplified parametric models for cost and weight, or with models which are costing a component with little or no ability to represent and/or simulate the material and/or processing costs. These model-based costing approaches are inadequate by today's standards and often dated by evolving technology advancements.

Scientists and engineers at the Directorate's Materials Process Design Branch, working with researchers from Case Western Reserve University and the University of Cincinnati, embarked on an in-house research project to enable a feature-based, product-process design capability. The Adaptive Modeling Language evolved as a result of further development by TechnoSoft, Inc. AML is an object-based modeling language for integrated product and/or process design, analysis and simulation, that facilitates *adaptive modeling* by enabling "object-coupling" between user-defined shapes, features and material processes. These processes and their associated knowledge incorporate constraints such as costs or weight to create optimal results in an interactive design environment.

AML is not a legacy system with technology upgrades; it is a compact CAD system that enables free-form, parametric, constraint-driven, feature-based design and incorporates a non-manifold solid-, surface-, and wireframe-modeling capability. AML knowledge-based architecture has proven to be beneficial for modeling just about any physical system from complex mechanical-optical systems to plaque build-up in blood vessels. Lockheed Martin has partnered with TechnoSoft to use AML as the underlying framework for the integrated development of a mechanical and optical design for an interactive gimbal for aircraft threat and detection systems, resulting in a 10-fold reduction in design cycles. TechnoSoft has also developed a "tow placement and ply design" system with the Boeing Company to automate process design of polymer-based laminate composites with dramatic savings projected. Ford Motor Company's initial application has been in the climate control area where AML has been used to design and deploy an "Interior Climate/Comfort Engineering" (ICCE) system to improve customer satisfaction, climate control system robustness, and reduce vehicle development costs. In the first year of implementation, ICCE reduced the company's vehicle development department's operating budget by more than 10 percent. Crankshaft, axle, hose routing, and suspension and steering systems are being looked at with growing interest by first-tier suppliers considering AML for designing power train components, manifolds and muffler systems. AML demonstrations and presentations have been requested by General Motors, Fiat, Mercedes, Rover and Renault. Volvo is using ALM to design new fuel efficient combustion chambers. AML is also being considered by a group of extrusion companies located in Northern Ohio and Western Pennsylvania for automation of die design and manufacturing for aluminum extrusions. Balcke-Durr, a German construction company, is using AML at its American-based engineering office to design cooling towers, chimneys and heat exchangers. Siemens will use the new program to design environmental control systems.

AML has enabled an improved understanding of what is needed in an integrated conceptual design environment and has helped identify the associated database requirements. AML also helps optimize engineering cycles, allowing for the evaluation of alternative designs and processes that optimize cost and reduce design-to-production time. Continued successful transfer of this technology to commercial industry could lead to dramatic advances, across a wide spectrum, benefiting both the nation's economy and quality of life.



Automobile climate control design developed using AML.

For more information, contact the Materials and Manufacturing Directorate's Technology Information Center at techinfo@ml.wpafb.af.mil or (937) 255-6469. Refer to item 97-165.

CALENDAR OF EVENTS

Interface Working Group Workshop (Ceramic Composites)
May 19-20, Cleveland, Ohio

95th MIL-HDBK-5 Coordination Meeting
April 27-May 1, San Diego, CA

Aeromat '98
June 15-18, Tysons Corner, VA

SAE Meeting
AE-8A
April 23-24, Tucson, AZ

Hydraulic Fluids and Seals Workshop
March 17-18, WPAFB, OH

Materials & Manufacturing Technology Series
April 24, WPAFB, OH

Optical Limiter Materials Modeling Meeting
May 18-22, WPAFB, OH

New Nondestructive Evaluation Technique Improves Inspection Of Aircraft Internal Wing Fuel Tank Structure

A nondestructive evaluation technique for detecting fatigue-induced cracks on internal wing fuel tank structures that is quicker and safer than conventional visual inspections has been developed by scientists at the Air Force Research Laboratory Materials and Manufacturing Directorate.

By permitting external inspection of internal weep holes in "wet wing" aircraft, the advanced ultrasonic transducer inspection system greatly improves the efficiency of pinpointing cracked weep holes in difficult-to-reach locations. Inspectors need only make manual checks of those holes shown to have cracks, substantially reducing the time required for inspections.

Several Air Force weapon systems are built with internal wing structures called wet wings, used as fuel tanks. Inside the wing, a series of vertical risers at right angles to the wing's leading edge serve as stiffeners. To provide balanced fuel flow and distribution during flight, quarter-inch weep holes are drilled through each of the stiffeners. Weep holes become sites where fatigue cracks tend to originate, primarily growing upward over time to weaken the stiffener and diminish wing integrity. While downward cracks also occur and are fairly easy to detect, cracks on the upper part of the weep hole are not readily detectable.

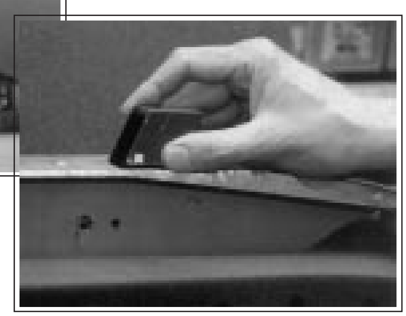
Weep hole cracks in C-141 Starlifter aircraft wings are a case in point. Excessive weep hole fatigue cracks caused the grounding of 45 C-141s in August 1993, while 116 more C-141s were prohibited from in-flight refueling. Earlier in 1993, all C-141s were held to 74 percent of normal load capacity, limiting their mission capability. All C-141s were inspected to determine weep hole cracking severity. To accomplish this, the fuel tanks had to be emptied and purged so that an operator could crawl inside each wing section and do a manual inspection using a special eddy current bore-hole transducer—a time-consuming, potentially hazardous operation.

Other Air Force weapon systems with wet wings include the A-10 Thunderbolt II, the F-15 Eagle, and the F-4 Phantom II (used today for drone duty). Engineers in the Nondestructive Evaluation Branch at the Air Force Research Laboratory Materials & Manufacturing Directorate worked with researchers from University of Dayton Research Institute of Dayton, Ohio and Advanced Quality Concepts of Columbus, Ohio, to find a faster, safer, more effective and convenient technique to locate weep hole cracking.

At the outset, the use of conventional ultrasonics was investigated, but it was found to be very difficult to detect cracks radiating upward from weep holes. To overcome this problem a dual element, split-aperture circumferential creeping ultrasonic transducer inspection system was developed. With it, when an ultrasonic signal encounters a weep hole it travels around it. If no signal comes back the hole is crack-free, but if some of the signal travels completely around the hole and a partial-travel echo comes back, the presence of a crack is indicated. This makes the inspection process much more efficient by previewing all holes from outside the wing. Only those holes with indicated cracks must be inspected from inside the wing, so overall inspection time is substantially reduced.

When system viability is developed for in field use, this technique will help wet wing weapon systems to more effectively maintain their mission capability.

For more information, contact the Materials and Manufacturing Directorate's Technology Information Center at techinfo@ml.wpafb.af.mil or (937) 255-6469. Refer to item 97-205.



Weep hole testing on the C-141

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The USAF Materials Technology Highlights is published quarterly to provide information on materials research and development activities by Air Force Research Laboratory's Materials & Manufacturing Directorate. For more information on subjects covered in "Highlights" or to be added to the "Highlights" mailing list, contact the Materials & Manufacturing Directorate Technology Information Center at (937) 255-6469 or e-mail at techinfo@ml.wpafb.af.mil. Approved for Public Release (ASC/PA#98-0622).

COMPLETED CONTRACTS

- Tribomaterials Precision Gimbal - SDIO84-89-C-0029
- Ultralight Weight Materials & Processes - F33615-91-C-5617
- PDES Application Subsets - F33615-91-C-5713
- Materials Processing Technology - F33615-92-C-5900
- Diamond Film Interface - I - F33615-92-C-5955
- High Durability Infrared Window - F33615-92-C-5969
- Integrated Product Process Initiative - F33615-93-C-5319
- Resin Transfer Molded Process Modeling - F33615-93-C-5337
- Silicon Carbide Contact Metallization - F33615-93-C-5347
- DARPA Funding - The Agile Manufacturing Information Infrastructure (AMII) - F33615-94-C-4400
- An Electronic Sector End-To-End Pilot - F33615-94-C-4431
- A Nondestructive Evaluation For Corrosion - F33615-94-C-5201
- Matrix-Coated Fiber-PVD Process For Fabrication of MMC - F33615-94-C-5214
- Casting Metrology And Design Model Validation - F33615-94-C-5220
- Cure Form Processing - F33615-95-C-5021
- Optical Fiber-Based NDI System For Aging Structures - F33615-95-2-5240
- Integrated Process Planning/Production Scheduling (IPPPS) - F33615-95-C-5523
- Improved Processing For Field Level Repair - II - F33615-95-C-5618
- High Performance E-beam Curable Resins For Affordable Polymer Matrix - F33615-96-C-5056
- Innovative Concepts In Affordable Composite Structures - F33615-96-C-5084
- Broadband Infrared Protective Shutter - F33615-96-C-5456
- Innovative Concepts In Affordable Composite Structures - F33615-96-C-5601
- Durable Fluorocarbon-Based Coatings For Aircraft - F33615-97-C-5093
- Novel High-Temperature Polymer/Inorganic Nanocomposites - F33615-97-C-5098
- Whole Wafer Thermal Measurements By Means of Laser - F33615-97-C-5133
- Real-time Whole Wafer Thermal Imaging For Semiconductor - F33615-97-C-5134
- 3D Engineering Workstation For Connected Simulations - F33615-97-C-5844

NEW CONTRACTS

- Lean Implementation - F33615-97-2-5153
- F-22 Radar Subarray Manufacturing Process Improvements - F33615-97-C-5159
- Hybrid Composites Manufacturing Technology Braiding Filament Production - F33615-98-C-5100
- Hybrid Composites Manufacturing Technology Braiding Filament Production - F33615-98-C-5101
- Detection Of Hidden Substructure Edges And Holes - F33615-98-C-5102
- Composite Affordability Initiative (CAI) Phase II Seattle - F33615-98-3-5103
- Composite Affordability Initiative (CAI) Phase II St Louis - F33615-98-3-5104
- Composite Affordability Initiative (CAI) Phase II Lockheed - F33615-98-3-5105
- Composite Affordability Initiative (CAI) Phase II Northrop - F33615-98-3-5106
- Computer Enhanced Eddy Current Detection Of Hidden Substructure Edges and Holes - F33615-98-C-5107
- Advanced Fasteners For Low Cost Airframe Assembly & Repair - F33615-98-C-5108
- Acoustic Wave Inspection of SOI Substrates - F33615-98-C-5111

UNITED STATES AIR FORCE MATERIALS TECHNOLOGY HIGHLIGHTS

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OFFICIAL BUSINESS